having distinct powers, and either of which may take the position of root or prime; these coexistent tones, whatever the previous independent ratio of string and reed as regards pitch, will always, when thus yoked together, be one an octave higher than the other. Singularly, too, it is not necessary that the lower of these fundamentals should be the pitch-note to the ear; its apparent character may be that of a sub-tone. Generally, the higher fundamental is the leading tone, and for this reason, that the predominance of one or of the other may be determined by character and by condition. In the reed, amplitude of excursion is the measure of its attainment of strength. In the string, tension is more effectual for power than amplitude is. String-tone thus gains by limitation of excursions of the string, whilst at the same time reed-tone is at a disadvantage from the restriction imposed by tension on the play of the reed. Contrariwise with a lighter string, power may be allotted to the reed, also by tubes, by partial occlusion of orifice, by coverings or shadings, the reed-tone can be modified in a variety of degrees; it may lead in trumpet-like vigour, or be heard only in quiet undertone accompanying the higher sound.

These two notes are rigorously exact in relative pitch, and when both have intensity, although different in kind, they produce other tones, as in the stop of the organ called the "Great Quint," the tone of one pipe added to another that produces a tone a fifth higher, gives rise to a third tone an octave lower, but never perfectly, except on the same conditions, exactness of pitch and intensity, with, as a rule, the higher note voiced the strongest. The reed and string necessarily, if preceding propositions are true, being in relation an octave apart, give rise to summation tones, first to the fifth, and these again to octave, tenth, and the rest in due order, but differing in intensity. In harmonic scale those possible would be octave, twelfth, superoctave, seventeenth, &c., and so here, if reckoned from the lowest tone as the root; but summation tones seem to require for their perfect production the same conditions as named above for difference tones; so that relatively the octave becomes by its voicing the leading tone, it fixes the pitch for the series in reference to itself, and thus the ear has cognisance of the tenth, not of the seventeenth. This major tenth to the tonic, so unmistakeable that it could not be gainsaid, was always a puzzle viewed as harmonic. Why it was so clear will readily be perceived when calculated as summation twice fulfilled.

The general supposition is, that because it is a string that is in action with the reed, therefore a stringy tone is in consequence obtained, the proof being that a stringy tone is actually heard. On the contrary, the true action of the string, whence arises the peculiarity of violin or violoncello, does not take place. What then? In a curious way effects are gained which naturally simulate the quality. By stringy quality musicians mean the tone of the bowed string. Amateurs talk eloquently in their way of the string-tone and its beautiful purity, of the reed-tone and its abominations, not heeding that the best judges of quality in sound class the stringy quality as the nearest allied to reed quality. Hence, organ-builders regard all the stops which best imitate the viola tribe, the geigens and gambas, as decidedly reedy in character, otherwise they would be poor representatves. The violoncello so characteristic in tone has always its introductory harmonics; these are sharp to the fundamental tone in which they merge, even as, I have shown in a former paper, the harmonics of the gamba organ-pipe are. Octaves of a free-string are always sharp to the note of the whole string. Then we have also the roughness, the grip, and bite of the bow. The sharpness is minute, yet sufficiently potent to give definite character. The ear is as easily deceived as the eye—the imitation may pass for the real. If we consider what is the effect on the ear of this sharpness, which does not reach the region of beats, we shall find it to be a breezy effect; in the delicate "voix celestes" of a fine organ when finished by true artists, we have it displayed—just a freshening touch of sharpness, and no more. From a breeze to a rough wind is only gradation of similarity. Return now to the combination of reed and string: the effect as of a stringy quality is gained by the breeziness of the outward stream of air distinctly heard, by the roughness of the abrupt closing and opening of passage to a highly-excited reed, by the tendency of a highly resilient reed to a more rapid pace, curbed though it inevitably is to the pace possible to the string it is paired with, thus adding an element of roughness to the sound-board, and in completeness of likeness there are the summation-tones mimicking those harmonics which are present in the fulness of the violoncello tone.

To assure those who would doubtfully accept the above interpretation, let me take an illustration of a practical nature as a verification. Why is it possible to make in a harmonium from free reeds alone a good imitation of violoncello quality? Because an analogous procedure can be adopted. This is the analysis of how it is done. Reeds of "eight-feet tone" of a firm character, rather slow in speech in consequence, but coming into play at a bound without hesitation; then in combination reeds of "sixteen-feet tone," these reeds finely curved, elastic, sensitive, quivering to a breath, their tone comes on at first as a breeze, it is sharp in a minute degree, but as the reeds gain power by amplitude, they flatten in pitch, as is the nature of bass reeds; ascending the scale, a small reed giving the twelfth may be added with advantage. In summary this is what we have: reeds relatively sharp to each other, the roughness, the breezy effect, and the accompanying harmonic offspring, together making the mimaphonic violoncello. Organ-pipe, violoncello, harmonium, and string-organ thus show a family likeness and give countenance to the interpretation.

The beauty of Mr. Hamilton's invention is that it is not limited to string-tone, that by giving predominance of power to either agent, reed or string, through long ranges of variation, many classes of tone as distinct as diapason, horn, flute, trumpet, and others can be satisfactorily imitated, and if its present promises of success are fulfilled, the name of string-organ by which it will be known will be amply justified.

HERMANN SMITH

P.S.—Mathematicians decide that the problem of the instrument is that of a loaded string. This appears to me a one-sided view, taken under limited experiments. Practically, some details of their conclusions are not corroborated; there are several elements entering into the composition not heeded, and a wider experience would show that the problem is equally that of a loaded reed. Here is an instance. I have in action a reed with pin attached; it sounds C sharp; and a string which, independently sounding, gives the F below. These, when conjoined, produce the G between. The note of the string is thus *raised* a whole tone; consequently the weight of the oscillating string is a load on the reed.—H. S.

The Law of Muscular Exhaustion and Restoration

YOUR issue of Jan. 28 is just received, containing a paper (vol. xi. p. 256) by Prof. Frank E. Nipher, wherein he condemns as "entirely unreliable" his first series of experiments on the subject of the exhaustion of the muscles of the arm by mechanical work. A like condemnation he pronounces in the February number of the *American Journal of Science*.

All the experiments in question, new as well as older, having been made at this laboratory, I beg leave to correct the above statements of Prof. Nipher. His new experiments are not so radically different from the old ones; on the contrary, both series demonstrate exactly the same general *law*. The true law is, as Prof. Jevons in his first communication to NATURE already felt it, *logarithmic*. So indeed vary most of the vital processes, because *molecularly* they are comparable to the vibrations of a pendulum in a resisting medium. (See Fechner, Exner, Wundt, Delboef, and others.) That the law has so long been overlooked, so far as muscular action is concerned, is probably due to the fact that the progressive restoration of the muscular tissue disturbs the function for small weights, while structural derangements (evidenced by *pain*) cause a like perturbation for higher values of the weight.

If we consider a system of muscles independent of continued circulation (no restoration) and keep the burden w (kgr.) low enough to cause no pain, then the *time* n (in seconds) during which the statical work can be sustained, or the *number of times* n, that the same *cycle* of motions can be performed until exhaustion takes place, I have found to be—

$$\left.\begin{aligned} n &= \frac{A}{B^w} \\ \text{or}\quad \log n &= a - b\,w \end{aligned}\right\} \qquad (1)$$

where $\log A = a$; $\log B = b$.

In the five series at hand the following are the values of the constants:—

		a	b
	I.—*Statical Work.*		
1.	Prof. Jevons, Series III., holding weight ...	2·433	0·1450
	II.—*Dynamical Work.*		
2.	Prof. Jevons, Series II., pulley and cord ...	1·968	0·0476

3. Prof. Nipher, old series, right arm	...	...	2·080	0·126
4. „ „ left arm	...	...	2·060	0·137
5. „ new series	...	...	2·560	0·194

Also Jevons: $a = 1·74 + 4·79\,b$; Nipher: $a = 1·28 + 6·25\,b$, very nearly.

To extend the law beyond the above physiological limits, introduce the *coefficient of restoration*, r, and of *pain*, p, in

$$N = (1 + r - p)\,n \qquad (2)$$

where both from theory and by above series of experiments,

$$r = \frac{H}{K^w} \qquad (3)$$

I have no doubt that p is of the same form; but none of the above series have been continued far enough to sufficiently confirm this. It is evident that p vanishes for small values of w, and r for large values of w.

These few remarks may be sufficient to show that the earlier as well as the late experiments of Prof. Nipher constitute a very valuable contribution to Animal Mechanics.

Iowa State University, Feb. 22 GUSTAVUS HINRICHS

The Height of Waves

YOUR correspondent Capt. William W. Kiddle, in NATURE, vol. xi. p. 386, speaking of the height of waves, says:—"This remarkable gale swept over a portion of the Atlantic which the French call 'Le trou de diable.' . . . When the wind sets strongly in this direction from the north-west, the sea rises in an incredibly short space of time, and at the close of a long winter gale it is a grand sight to watch the great waves," &c. The question is then asked, why this remarkable phenomenon occurs with a north-west gale, whilst with an equally strong south-west or southerly gale the effect is insignificant?

I think an explanation may be given thus:—"Le trou de diable"—whose position, roughly calculated, is 45° N. and 40° W.—is, roundly speaking, about the centre of the Gulf Stream in that locality, and during a strong north-west gale the wind meets the Gulf current at a good angle. The force of this encounter has a tendency to drive the stream out of its course. The velocity of the water-current and its mass are, however, so great that it yields but slightly, if at all; consequently, the force of the wind exerts itself to a large extent in banking up the water to the production of unusually high waves.

From an analogous course of reasoning, it is apparent that a south-west or southerly wind will not have a similar effect; for both stream and wind are then travelling in the same, or nearly the same, direction. The force of a gale from the south-west or south has no counter water-force to oppose it; hence its high velocity tends simply to increase that of the Gulf Stream, as well as to beat down its surface to the prevention of any extraordinary waves. ARTHUR R. GRANVILLE

Islington, March 22

Thermometer Scales

THE thermometric scale referred to by Mr. T. Southwell (NATURE, vol. xi. p. 286) was, I believe, one used and invented by Fowler, in which 0 = 55° Fahr., 75 above = 102° Fahr., and 80 below = + 5° Fahr.

The above equivalents are only approximately given. For full description, &c., see "Essays on Construction and Graduation of Thermometers," by Geo. Martine, M.D, 1772: Edinburgh.

I have failed so far in discovering the scale of Linnæus alluded to, and shall likewise feel indebted to any of your readers who will describe it. S. G. DENTON

34, Foreign Street, Brixton, March 23

Accidental Importation of Molluscs and Insects

I OBSERVE in NATURE (vol. xi. p. 394) a note from the *Saar und Mosel Zeitung* on the introduction of a mollusc into the Moselle near Trèves. Though the name of the species is not mentioned, I presume that *Dreissena polymorpha* is the mollusc in question, a species known to inhabit Britain since 1824, and supposed to have been introduced with timber from Eastern or Northern Europe. It is exceedingly prolific. An instance of how this species may be introduced came under my notice a few years ago. A friend showed me some shells that he had found attached to logs of wood lying on a railway truck. These proved to be alive when put into a cup of water; and if the logs in question had been deposited on the banks of the Tay within reach of the tide, as is often the case (I should have said that the truck was on a siding near Perth Harbour), we would no doubt have found *Dreissena* in abundance in the course of a few years. As this mollusc lives in brackish water as well as in fresh, it is no doubt in a manner similar to what I have mentioned that it has been introduced into and spread through Britain. Another shell, *Planorbis dilatatus*, a North American species, was found a few years ago living in a canal near Manchester, and is supposed to have been introduced with raw cotton. Recently another case of importation of living shells came under my notice. When looking at some bales of *Typha* from the Nile, imported into Aberdeenshire as a material for paper manufacture, I observed some shells sticking in the dry mud adhering to the roots of the *Typha*. On putting some of these into water they were found to be alive, though a good many months had elapsed since the *Typha* had been gathered. The shells appear to belong to *Bythinia*, but I have not yet determined the species. It is, perhaps, not very likely that if these shells had found their way into the Aberdeenshire rivers they would have survived.

Land molluscs are sometimes introduced, and several European species have in this manner become naturalised, in North America.

Apropos of the fears that have been expressed that the Colorado Potato Beetle (*Doryphora decemlineata*) may be introduced into Europe and prove destructive, the Entomological Society of Belgium has been recently discussing the matter, and has arrived at the conclusion that the fears regarding this insect are much exaggerated. M. Oswald de Kerchove, of Denterghem, has just published a very complete memoir upon this beetle. He thinks that it is very improbable that the *Doryphora* will be introduced, and at any rate that the prohibition of the importation of American potatoes is unnecessary, as it lives upon many other plants than *Solanaceæ*. M. de Kerchove further deprecates the use of the arsenite of copper (Scheele's green), so much employed by the Americans for the destruction of the beetle, as such a dangerous substance ought not to be made common.

Is not the "Blood Louse," so destructive to apple-trees, mentioned by the *Kölnische Zeitung* (NATURE, *l.c.*), the homopterous *Eriosoma lanigera*, the so-called American Bug, already too well known in this country?

Perth F. BUCHANAN WHITE

Fall of a Meteor at Orleans

IN the "Notes" of March 18 (vol. xi. p. 396) it is stated that a meteor fell in a street at Orleans on the 9th inst. The time of the fall is not mentioned, but it would be interesting to know if the meteor were the same that was observed from here on the evening of that day about eight o'clock. It was very brilliant, as bright as Sirius, and moved slowly from a position a few degrees to the east of Sirius, in a south-easterly direction, the path making with the horizon an angle of about 60°.

Cooper's Hill, March 27 HERBERT M'LEOD

Proposed Aquarium in Edinburgh

I AM happy to be able to inform you that the suggestion originally made in NATURE, that a large aquarium should be formed in Edinburgh, is likely soon to be adopted. A company named the "Edinburgh Winter-Garden, Theatre, and Aquarium Company (Limited)" proposes to provide at the west end of Edinburgh a large and well-stocked aquarium on a scale not inferior to those of Brighton and the Crystal Palace.

Edinburgh, March 26 RALPH RICHARDSON

Acherontia Atropos

CAN any of your readers throw any light on the *raison d'être* of the dimorphism of the larva of the Death's-head Moth (*Acherontia atropos*)? Some years ago I found five larvæ of this insect on a bush of jasmine. They were all probably offspring of one female. Two of them were of the dark chocolate-coloured variety so strikingly dissimilar to the normal or commoner type. The *imago* of one of the dark-coloured larvæ differed in no respect that I could perceive from the ordinary form. It has occurred to me that the dark variety may be due to its simulating the dead, withered, blighted, or diseased shoots of the potato, as its commoner brother does the healthy leaves and stalks.

Taunton FRED. P. JOHNSON